Allocation of Dynamic Bandwidth to Enhance Quality of Service in Internet of Things using Machine Learning

A

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Shekhar

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Under the Supervision of

Dr. Gaurav Bhandari

and

Dr. Shudhanshu Tyagi

ICFAI Tech School
The ICFAI University, Dehradun
2022

The ICFAI University, Dehradun

Candidate's Declaration

I, **Shekhar**, declare that the synopsis entitled, **"Allocation of Dynamic Bandwidth to Enhance Quality of Service in Internet of Things using Machine Learning"** being submitted in the partial fulfillment of the requirement for the award of the degree of Doctor of Philosophy in Engineering under ICFAI Tech School, The ICFAI University, Dehradun during the academic year 2022-23.

It is the work that is expected to carried out under the supervision of Dr. Gaurav Bhandari and Co-Supervisor of Dr. Shudhanshu Tyagi. It is further declared that the synopsis is within the plagiarism limit and copy of the same is attached as per the University norms.

Date: 08.03.2022

Shekhar
Research Scholar
ICFAI Tech School
The ICFAI University, Dehradun.

The ICFAI University, Dehradun

CERTIFICATE

This is to certify that the thesis entitled, **"Allocation of Dynamic Bandwidth to Enhance Quality of Service in Internet of Things using Machine Learning"** is an original piece of work done by **Shekhar** under our supervision being submitted in the partial fulfillment of the requirement for the award of the degree of Doctor of Philosophy in Engineering under ICFAI Tech School, The ICFAI University, Dehradun during the academic year 2022-23.

Further, it is certified that the synopsis is within the plagiarism limit and copy of the same is attached as per the University norms.

08/03/22

Signature of the Supervisor in full

Dr. Gaurav Bhandari
Associate Professor
ICFAI Tech School
The ICFAI University, Dehradun.

Signature of the Co-Supervisor in full

Dr. Shudhanshu Tyagi
Assistant Professor, ECED
Thapar Institute of Engg.
Patiala, Punjab

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ABSTRACT

- Internet of Things (IoT) is one of the most used jargon in the present century; it has become a buzzword in the industry, it leads to industrial 4.0 revolution. There are several reports which indicates that the number of IoT devices will be reached by 50 billion and more. Some of the countries will extend about two third of these IoT devices itself. There are several issues in IoT may occur due to low processing capabilities and low bandwidth allocation. Some of the issues are security, heterogeneity, low power, and so on. Allocating bandwidth to billions of IoT devices will be difficult with current infrastructure. The Improved Dynamic Bandwidth Allocation (IDBA) technique is presented to overcome this issue by providing an uninterrupted bandwidth supply and improving the quality of service in IoT devices. The IDBA algorithm is provided a bandwidth dataset from smart home-based IoT devices. Based on the utilization level, data sets will be collected from various IoT devices. The IoT device can be clustered using a variety of clustering algorithms.

1. Introduction

The IoT defines the networks of connected Things, enabled with sensors, actuators allowed to send, receive data over the internet. It comprises the devices from smart home appliances, health care devices, Agriculture, and Industrial automation things. IoT has become a buzzword in the industry. It is inevitable in the 21st century. It leads to industrial 4.0 revolution. Normal embedded systems simply apply only ON and OFF mechanism over the devices through internet. However, IoT systems not only control the devices over the internet; moreover, it gathers the data from devices and stores at cloud for data analytics. Based on the data analytics it lets the system to work on its own without human intervention. Supporting quality-based services with existing infrastructure will be a challenge as the number of devices grows from millions to billions. Furthermore, because IoT devices are weakly connected and heterogeneous, the smart home based on several IoT devices becomes even more complicated. Enterprises are seeking relentlessly to boost network capacity and service quality. Efficient bandwidth management technique is needed to meet the requirement of guaranteed bandwidth, yet, adding more bandwidth does not appear to give permanent answers. Rather of merely adding more bandwidth, an Improved Dynamic Bandwidth Allocation (IDBA) algorithm is an innovative technique. Existing dynamic bandwidth allocation algorithms are unable to handle large numbers of IoT devices, necessitating the use optimization techniques, such as machine-learning approaches, to automatically observe consumption patterns and aggregate them into clusters. Several machine learning techniques and regression techniques discussed in the Literature review section were used to adapt dynamic frequency and bandwidth allocation, such as a composite of clustering and learning, which helped to adapt efficient bandwidth management strategies to the needs of massive IoT applications. Figure 1 demonstrate the distinguish layers of IoT applications such as perception layer, wireless sensor layer, network or cloud layer, and android layer.

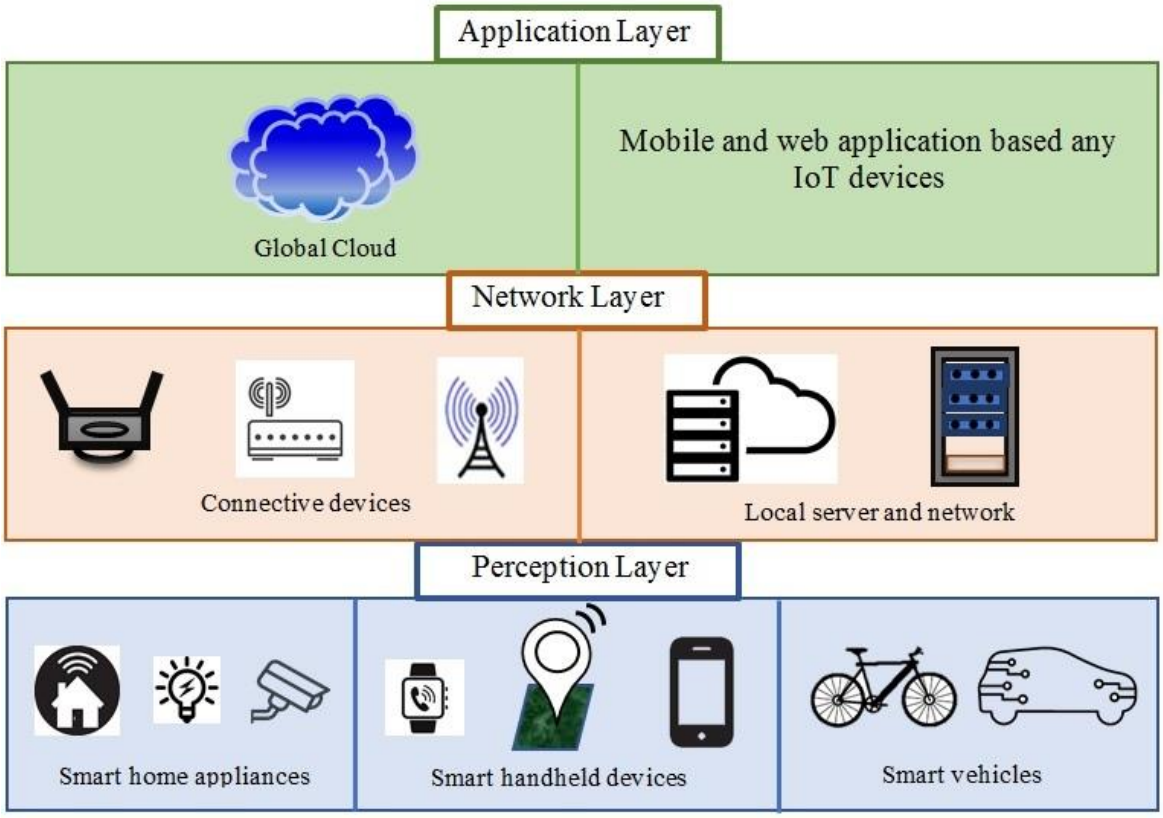

Fig.1.1: IoT Layers

2. IoT Application

There are several recent incidences which motivates the research toward IoT application. Every sub-domain of the IoT field providing the market share with application area. Figure 2 demonstrate the market share of distinguish IoT applications.

Manufacturing: IoT enabled Industry works with robotic machinery reinforced with real-time analytics of supply chains and equipment.

Healthcare: IoT enabled healthcare management system supports portable health monitoring, pharmaceutical safeguard and electronic recordkeeping.

Retail: IoT enabled retail management predicting customer interests based on purchase history, surfing in smartphone and supports Inventory tracking.

Figure 2.1: Market share of IoT technology across different applications

Agriculture: Through IoT sensors installed in soil to check acidity levels, temperature, and variables that assist framers boost crop yields, IoT devices may provide information about rainfall, pest infestation, and soil nutrition.

Surveillance: Safer homes, workplaces, and towns are made possible by IoT-enabled biometric, facial recognition locks, remote sensors, and security cameras. Smart cities: Many Developing countries constructs smart cities with IoT technology, which ensures smart city features such, that waste recycling system, smart streetlights. The light automatically brightens when more people in the area and dim when nobody around, smart parking facility where parking sensors sending signal whether parking spot available, many more facilities like intelligent transportation, traffic management, smart grid and smart city maintenance for smart life style at smart cities.

Transportation Autonomous vehicle services, traffic warnings, emergency roadside assistance, and notifications of part maintenance are just a few of the services that IoT-enabled vehicles offer at the forefront of the automotive industry. Beyond a vehicle's safety, IoT can also regulate things like fuel usage and idle time. Drivers are relieved of tedious tasks like manual monitoring thanks to this, which also lowers business costs.

Smart Parking: Parking congestion can be completely eliminated with IoT-based smart parking. This technology includes dashboards that use data analytics, parking sensors, security cameras, wireless communication protocols, and smart parking meters. Future of the smart parking technology is predicted to be significantly impacted by autonomous vehicles.

3. Motivation and Challenges

IoT has become inevitable in the 21st century, In the IoT era all the things such as objects, machineries, human, animals and everything in the world will be connected with internet. In connection with IoT two important factors are the concern: IP address and bandwidth. IPV6 offers ample amount of ip address to connect all the things with internet. In order to provide Quality of Service to IoT devices with existing bandwidth is very challenge factor. Proposed Improved Dynamic Bandwidth Allocation (IDBA) technique handling the bandwidth management

efficiently with the existing infrastructure. Many dynamic bandwidth allocation techniques, such as PSA and DBA, are utilised on the internet. Such algorithms, on the other hand, are just concerned with throughput and delay, and are not linked to a bandwidth planning process. Some IoT devices send only a few bytes of data per day, such as smart locks and garage doors, which send signals to the gateway on a regular basis. The results of our IDBA Simulations were used to assess different types of applications. In terms of bandwidth usage, reduced delay, fewer packet loss, and increased throughput, simulation results suggest that our proposed technique outperforms other dynamic bandwidth allocation methods and **Challenges** for IoT devices increasing from millions to billions, the amount of data IoT devices collect and transmit can increase which in turn adds to need for more bandwidth. For example, bandwidth need in smartphone increased when it able to transmit images and stream videos. Such that when all the things in the world like automobiles to agriculture plants connected with internet will produce zettabytes of data over the internet. Handling mass data with existing infrastructure will be challenging factor. It requires highly improved bandwidth management techniques to providing Quality of Service to the entire connected IoT devices.

4. Literature Review

Uzawa et al., 2020 densely deployed distinguish access points for wireless network to improve the bandwidth allocation. According to the authors, time-division multiplexing is a better cost-effective solution for network slicing. Zhang et al., 2021 proposed many-to-many bandwidth allocation to communicate among the UAVs. To maximize the throughput of the System, they have used framework which is based on dynamic multi-connectivity with multiple servers. The results of experiments demonstrate the low latency and complexity, and better accuracy in terms of many-to-many matching algorithms. Here, in this section, we demonstrate the Dynamic bandwidth allocation method to IoT devices involves different steps such as clustering devices based on bandwidth usage, measuring on- demand prediction in every cluster, Dynamic bandwidth allocation, Enhance Quality of Service, the previous works related to clustering devices, Dynamic bandwidth allocation (DBA) techniques and Quality of Services are discussed in this section.

4.1 Enhance Quality of Services (QoS)

Yoga et al, 2021 presented a system for the creation of IoT system monitoring and control to control bandwidth in public areas. To manage bandwidth, they proposed an elastic wireless local area network. The Raspberry Pi model, a WLAN access point, and a few intelligent sensors were used to implement the system. With the quantity of data and sensors, the system operated

effectively.

Offers solutions to meet the QoS requirements for diverse operations, particularly for relay stations. The QoS factor suffers when bandwidth is limited due to the rtps pattern, which increases throughput in accordance with the bandwidth supply. (Cheng et al., 2010).

Provides statistical QoS control to session level traffic, this prototype ensures QoS in reliable transmission, where are as not suitable to unreliable transmission such as wireless medium, most of the IoT devices works under wireless medium, hence this technique not ensuring QoS to IoT devices (Ray et al., 2016). It aims to reduce system latency and to optimize the total number of tasks based on graph coloring algorithm, applying this technique over IoT devices has set of constraint such as not supporting dynamic data (Raad et al., 2019).

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Mohandas et al., 2021 addressed the issues which are related to the dynamic bandwidth allocation in IoT system. Authors proposed an algorithm based on machine learning intelligent system to utilize the pattern observed from the past behavior. They demonstrate the better results with the improved quality of services with uninterrupted bandwidth for critical IoT applications.

4.2 Dynamic Bandwidth Allocation

Several researchers have done research on dynamic bandwidth allocation based on demand bandwidth. The popular techniques used for dynamic bandwidth allocation are: Priority based, Delay based, Traffic pattern based and clustering based techniques.

PRIORITY BASED TECHNIQUES

High priority devices receive greater bandwidth when using priority-based strategies than low priority devices. DBA technique based on bandwidth extraction from lightly loaded to heavily loaded devices. The master-slave control technique used by Internet of Things devices does not support the QoS factor. The DBA technique operates on a priority-based packet system, with high priority packets being served first and with the least amount of delay, low priority packets being stored in a large buffer, and queue length being utilized as a weighting factor for serving packets. Average packet delays for the HSSR DBA technique are 950us, for the MAC DBA technique they are 800us, and for the MCA BDA technique they are 150us. (Zhao et al., 2014). MAC layer modifications are used to divide bandwidth among different priority communications. Queuing model that allows for a slower transfer rate for lower priority packets and a faster transfer rate for higher priority real-time packets. MAC layer incorporates priority and queuing mechanism to ensure critical data delivery for prioritized device. This technique allocated 6 Mbps bandwidth to high priority devices, concurrently low priority devices being allocated only 1.5 Mpbs (Wamser et al., 2014). The Priority Scheduling Algorithm (PSA) is used to distribute resources to devices that

require immediate attention in order to ensure a higher level of QoS. This algorithm offers an LTE broadcasting scheme to avoid network access for low priority devices, when high priority devices demand more bandwidth. This Improved technique has only 40 percent packet loss where normal technique has 90 percent packet loss in low bandwidth range. The results show that lower priority devices compromised its quality in low bandwidth range (Aiswariya et al., 2015). To allocate bandwidth to multiple front-end devices with priority media transfer services, a novel network bandwidth allocation and management technique was developed. NNBA technique increase the throughput from 80 to 88 percent from naïve technique. In this technique bandwidth allocated based on priority, it results in increasing latency to low priority devices (Harum et al., 2018).

Proposed the DUP-TRMA techniques, which works, based on lower bound logic and Throughput maximum resource allocation (TRMA) scheme, it allocates bandwidth based on user's priority. DUP –TRMA attains 4% improvement in performance over conventional RPA techniques (Pratap et al., 2019).

Torres et al., 2021 presented a dynamic resource allocation technique which is based on allocation of bandwidth and supports new trends in IoT system. Authors proposed a model BAMSDN which is a system for bandwidth allocation using software defined network to allocate the resources dynamically. The experimental results demonstrate that BAM with SDN is effective and flex.

DELAY BASED TECHNIQUES

Presented (PBA-CDC) proportional bandwidth allocation approach to address discrimination issue in wireless networks. It followed queue management system and channel access mechanism to attain fair bandwidth distribution for local and relay users. The PBA-CDC simulation model shows that, it achieves better QoE for delay sensitive application than existing 802.11e and TXOP schemes. 802.11e and TXOP has 290 and 200 ms delay in heavy load, where PBA-CDC have only 150 ms delay. To improve QoE, this technique considered only the delay parameter, where traffic pattern and resource allocation scheme missing here (Amaral et al., 2016).

TRAFFIC PATTERN BASED TECHNIQUES

Devices can turn off their radio interfaces and go to sleep in various patterns using the Discontinuous reception/transmission (DRX/DTX) mechanism. The goal of this study is to figure out how to get the most out of low-traffic devices' idle bandwidth. Although DRX/DTX mechanisms focus on ensuring QoS, particularly in terms of packet loss, delay, and traffic bit rate, they are not suited for important IoT devices because idle state is not

possible (Liang et al., 2013).

A SDN-based traffic classification architecture that collects traffic patterns from enterprise networks using the open flow protocol. Supervised learning techniques applied to classify the traffic pattern obtained from enterprise network. Dynamic bandwidth allocation based on demand prediction is lacking here (Fan et al., 2016).

Analyses network trace of IoT devices and device behavior-based network traffic pattern. Then it use the data derived from the pattern to analyze how device behavior affect power consumption and bandwidth allocation. This research specifically focus to understand the behavior of Home IoT devices in different state such as idle, active and remote access, accordance with allocating bandwidth dynamically to on demand IoT devices. In pattern based bandwidth allocation technique, low priority device service affected in low bandwidth range (Lin et al., 2018).

A variety of network delay is estimated using ANN for various applications. In homogeneous devices, measuring bandwidth is challenging. Dynamic frequency and bandwidth assignments (DFBA) are utilized in small cell network deployments. The DFBA approach is not ideal for IoT devices that are heterogeneously coupled (Cai et al., 2016). “Using Semi-Sequential Multiple Relays to Break Bandwidth Limitations for Mission-Critical IoT” TBM approach that focuses on bandwidth limiting to deliver low latency services for crucial tasks. The TBM technique reduces essential task transmission time by up to 76%. (Dalla Cia et al., 2017).

“A Design for Saving Bandwidth and Doubling the Number of Connected Devices in the Non-Orthogonal Narrowband Internet of Things” By adopting a bandwidth reduced signal waveform, OFDM can increase the number of connected devices. By compressing the bandwidth signal waveform, the QoS of connected devices is jeopardised (Manshahia et al., 2018).

“The SDBAT approach allots bandwidth based on statistical information from a future user's domain. It is referred to as "A Smart Clustering-Based Approach to Wireless Network Dynamic Bandwidth Allocation." Key device throughput is impacted by balancing bandwidth load based on user or node mobility. Mohammed et al., 2018).

“User Activity Recognition in Smart Homes Using Pattern Clustering Applied to Temporal ANN Algorithm” “User Activity Recognition in Smart Homes Using Pattern Clustering Applied to Temporal ANN Algorithm”

Technique of unsupervised learning: the artificial neural network based on Allen’s temporal relations is utilised in the smart home environment to recognise and anticipate user actions personal space. In the presence of more sensitive sensors, this technique may result in

irrelevant qualities (joshi et al., 2020).

Hatem et al., 2019 proposed deep learning-based solutions for the allocation of dynamic bandwidth in future access network. Authors proposed next-generation passive optical network to control the message exchange between terminal and network unit for the enhancement of bandwidth allocation. They focused on control the overheads due to request-response procedure in the proposed technique.

Nkosi et al., 2020 used an intelligent system to enhance the dynamic bandwidth allocation for smart home devices and network. They proposed an algorithm for dynamic bandwidth allocation as a solution of bottleneck incurred in home network. The algorithm is deal with the allocation of bandwidth efficiently with integration of particle swarm optimization, and offline Cooperative algorithm. The experimental result obtained the 92% accuracy with an average delay of 0.8 sec.

4.3 Clustering Devices

The technique of grouping IoT devices into various clusters according to characteristics of bandwidth utilization, such as Low, Medium, and High, is known as clustering. Clustering, which aids in allocating bandwidth from threshold to upper level, is a crucial step in categorizing devices. IoT clustering requires keeping track of a number of variables, including bandwidth usage, data transmission, and power consumption. IoT devices regularly produce large amounts of data that are uploaded to clouds for data analytics.

DBSCAN and Auto Class By forming a limited subset of clusters in the majority of connections, Auto Class produces the best accuracy when clustering analysis is used to detect groups of similar traffic at the transport layer. To estimate the maximum and minimum parameters, pseudo-random numbers are employed to calculate the mean and variance. However, the Auto Class clustering algorithm only obtains small subgroups. Mean and variance, pseudo-random numbers, and clustering in IoT devices are complicated and difficult. (Jeffrey et al., 2006).

Through artificial neural networks, K-pattern clustering showed its effectiveness in classifying and defining the pattern of user activity. However, this technique has limitations, such as producing subpar results because related activities in IoT nodes are similar. (joshi et al., 2020).

An algorithm for pattern-based clustering that extracts the potential load in a set amount of time. This technique is utilized for consumer domain statistics information. Large IoT devices cannot efficiently use their computational bandwidth. (Mohammed et al., 2016).

Data with a high degree of similarity are gathered, and then sequence file technology is used

to help the data converge into a cluster that is more similar. When using an IoT dataset with dynamic data as input, the sequence file technique is inappropriate. (Venkatesh et al., 2017).

Sequence file technology is used to help the data converge into a cluster that is more similar after being collected with a high degree of similarity. The sequence file technique is inappropriate when used with an IoT dataset that contains dynamic data as input. (Mohandas et al., 2018).

Hu et al., 2018 proposed an intelligent mechanism for network bandwidth allocation which can be applicable on front edge of IoT devices. The proposed system monitored the performance of network throughput among the integration of IoT system and cloud servers. The experimental results demonstrated that the media files can be transferred through the improved bandwidth allocation techniques in IoT network. Identify initial clusters centers by combining the Max-minimum distance with mixed data density to improve cluster performance, devices in IoT some time goes to idle state, it is complicated to finding the average value in bandwidth dataset (Hatem et al., 2019).

The results of the cluster considered consider the distribution of the most significant elements of the cluster in terms of either histogram or pdf, this approach more suitable for images, where bandwidth data measured in Mbps (Srinidhi et al., 2019).

Table 1: Comparison between existing and applied strategies

References	Contribution	Outcome	Research Gap
Imran et al., 2021	Discussed major challenges, techniques, and security issues Related to IoT.	Investigated IoT concepts, challenges, and solutions used to address These challenges.	Lack of standard SDN based solution for IoT security.
Zhang et al., 2021	Zhang et al., 2021 proposed many-to-many bandwidth allocation to Communicate among the UAVs.	The results of experiments demonstrate the low latency and complexity, and better accuracy in terms of many-to-many matching algorithms	Optimized results are having alternative solution In terms of communication.

Venkatesh *et al.*, 2017	Authors collecting data with high similar value, then applies sequence file	Sequence file technique not suitable to IoT dataset,	A real-time intelligent system is required for the
Torres et al., 2021	They presented a dynamic resource allocation technique whichis based on allocation of bandwidth and supportsnew trends in IoT system.	Authors proposed a model BAMSDN which is a system for bandwidth allocation using software defined network to allocate the resources Dynamically.	The experimental results demonstrate that BAM with SDN is effective and flexible.

Yoga et al,2021	Authors presented a system for the development of Monitoring and controlling of IoT system to manage the bandwidth in public areas.	They posed Elastic wireless local area network for the Management of bandwidth. The system was implemented using WLAN access point and Raspberry pi model and Some smart sensors.	The system performed well with the amount of data and sensors. However, the system can be build using more sensors and IoT systems.
Mohandas et al., 2021	Authors addressed the issues which are related to the dynamic bandwidth allocation in IoT system.	Authors proposed an algorithm based on machine learning intelligent system to utilize the patternobserved from the pastbehavior.	They demonstrate the better results with the improved quality of services with uninterrupted bandwidth for critical IoT Applications.
Nkosi et al., 2020	They used an intelligent system to enhance the dynamic bandwidth allocation for smart home devices and network.	They proposed an algorithm for dynamic bandwidth allocation as a solution of bottleneck incurred in home Network. The algorithm is deal with the allocation of bandwidth efficiently with integration of particle swarm optimization, and offline cooperative algorithm	The experimental result obtained the 92% accuracy with an average delay of 0.8 sec. The accuracy can be improved with the hybrid system
Ahmad et al., 2020	To improve the QoS of IoT network, a conceptual model is proposed for distributed Fog computing.	The proposed model provided the 99% accuracy with SVM classifier.	It provides the low latency with local processed data.

Uzawa et al., 2020	Propose a dynamic bandwidth allocation which satisfied the requirements of sub-Networks.	Experimental study demonstrates low-latency, auto-discovery process, and guarantee Bandwidth.	It will be a significant solution with integrated 5G- IoT.
Hossen *et al*., 2020	Performance of DEE DBA is compared with ALDBA and ALDBM scheme at the uppermost offered load of 1.0, this scheme provides 30% and 37% lesser TE consumption than ALDBA and ALDBM Schemes respectively.	Proposed Delay and Energy efficient DBA system to reduce energy consumption and end-to-end packet delay of the HOWSN.	Safeguard time is required for Protecting the packets from threats; hence it increases the overhead, bandwidth consumption.
Hatem et al., 2019	Authors proposed deep learning-based solutions for the allocation of dynamic bandwidth in future access network.	Authors proposed next-generation passive optical network to control the message exchange between terminal and network	They focused on control the overheads due to request-response procedure in the Proposed technique.

	Home devices and network.	Network. The algorithm is deal with the allocation of bandwidth efficiently with integration of particle swarm optimization, and offline Cooperative algorithm.	Accuracy can be improved with the hybrid system.
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Hatem et al., 2019	Authors proposed deep learning-based solutions for the allocation of dynamic bandwidth in future access network.	Authors proposed next-generation passive optical network to control the message exchange between terminal and network unit for the enhancement of bandwidth allocation	They focused on control the overheads due to request-response procedure in the Proposed technique.

Raad et al., 2019	The major aim is to reduce system latency and IoT devices has set of constraint such as not supporting dynamic data	Generate optimized number of tasks based on graph coloring algorithms.	It needs to improve distinguish performance parameters such as False detection rate.
Srinidhi *et al.*, 2019	Authors proposed the DUP-TRMA techniques, which works, based on lower bound logic and Throughput maximum resource allocation (TRMA) scheme, it allocates bandwidth Based on user's priority.	DUP –TRMA attains 4% improvement in performance over Conventional RPA techniques.	The accuracy of the system can be improved by using the particle swarm optimization algorithm.
Hatem *et al.*, 2019	This approach is more suitable for images, where bandwidth data measured in Mbps.	The results of the cluster considered the distribution of the most significant elements of the cluster in terms of Either histogram or pdf.	The real-time implementation of bandwidth enhancement is required for better QoS.
Manshahia et al., 2018	A Design for Saving Bandwidth and Doubling the Number of Connected Devices in the Non-Orthogonal	Narrowband Internet of Things" By adopting a bandwidth reduced signal waveform, OFDM can increase the number of connected devices.	By compressing the bandwidth signal waveform, the QoS of connected devices is jeopardized.
Mohammed et al., 2018	A Smart Clustering-Based Approach to Wireless Network Dynamic Bandwidth Allocation.	The SDBAT approach assigns bandwidth based on statistical data from a potential user's domain.	Balancing bandwidth load based on user or node mobility has an

			impact on key device Throughput.
Lin *et al.*, 2018	They analyses network trace of IoT devices and device behavior-based network traffic pattern. Then it use the data derived from the pattern to analyze how device behavior affect power consumption and bandwidth allocation.	This research specifically focusses to understand the behavior of Home IoT devices in different state such as idle, active and remote access, accordance with allocating bandwidth dynamically to on demand IoT devices.	In pattern-based bandwidth allocation technique, low priority device service affected in low bandwidth range.
Hu et al., 2018	Authors proposed an intelligent mechanism for network bandwidth allocation which can be applicable on front edge of IoT devices.	The proposed system monitored the performance of network throughput among the integration of IoT system and cloud servers.	The experimental results demonstrated that the media files can be transferred through the improved bandwidth allocation techniques in IoT Network.
Mohandas *et al.*, 2018	Graph and Heuristic approaches used in performing clustering based on the parameter's residual energy and neighbor counts conditional on the requirement of an IoT Application.	Clustering using the parameters residual energy and neighbor counts are complex and tricky in dynamical IoT.	IoT systems must improve the QoS using bandwidth allocation.

	technology for data convergence in to a cluster with more Resemblance.	Where dynamic data served as input.	Implementation of dynamic bandwidth allocation.

5. Research Gap

The foundation of IoT is connecting anything to the internet, and according to Ericsson, there will be 30 billion IoT devices globally by 2022. By the advent of the Internet of Things, gadgets will produce 300 Zettabytes of data online. Anything that connects to the internet through IPv6 address faces challenges handling bandwidth and assuring quality of service in a vast IoT context. Existing DBA techniques only use additional bandwidth to handle on-demand bandwidth and QoS, not bandwidth management. IoT devices are not well-suited to most dynamic bandwidth allocation algorithms. There are no techniques for supporting both wired and wireless devices. The suggested technique effectively manages bandwidth using machine learning techniques. Even with low bandwidth, it guarantees low latency, high reliability, and an increase in throughput of up to 96% for IoT devices.

6. Research Objectives

According to the findings from literature survey and gaps, we have identified some of the objectives as follows:

1. Performance analysis of proposed scheme with respect to state-of- art scheme.
2. To develop an improved dynamic bandwidth allocation with machine learning techniques to prove that IDBA techniques enhance the Quality of Services as low latency, increasing throughput etc.
3. To develop bandwidth utilization pattern utilized IoT device and applies linear regression model to predict on demand bandwidth and threshold value for each category.
4. To implement the linear regression and Artificial Intelligence technique adapted in Improved Dynamic Bandwidth Allocation (IDBA) technique to optimize bandwidth usage in IoT devices to ensure QoS.

7. Research Methodology

IoT devices sending and receiving data to internet through gateway, device bandwidth consumption data observed and categorized using clustering techniques. Data patterns

learned through regression technique used to predict on demand bandwidth, this rule passed on to IDBA optimization for improving Quality of Service in IoT.

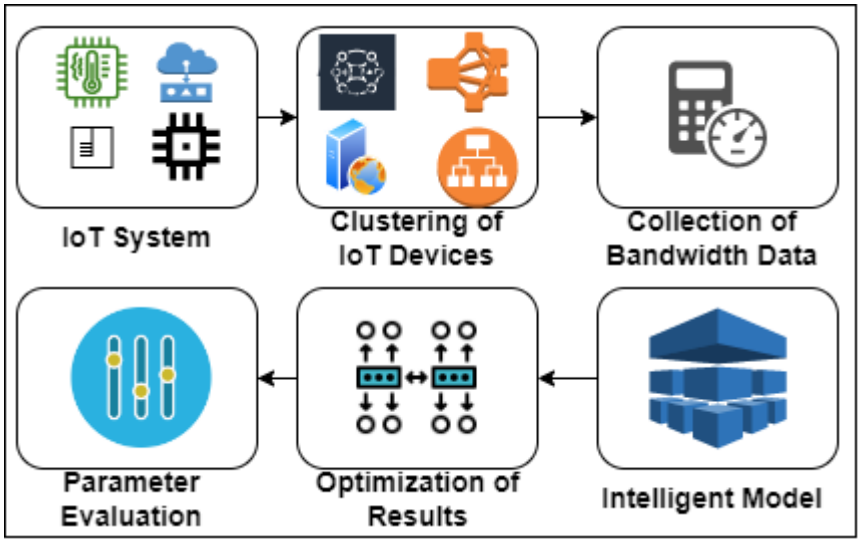

Fig 7.1: Proposed Methodology

In our model system architecture, consist of six phases: IoT devices, IoT devices bandwidth data, clustering IoT devices, machine learning, IDBA optimization, Quality of Service.

Step 1- IoT System:

Infant and toddlers require continues care but we cannot be in its every hour of the day. Thatis the intent of baby monitors, Audio and video feature enabled infant care system let the parents watch and listen the child from another room. In the field of healthcare remote monitoring have made possible through IoT enabled system. Deliver the capacity to keep patients well and safe, and enable the doctors to provide splendid treatment. It also increasedpatient interaction and satisfaction with doctors. Moreover, remote health monitoring systemsignificantly reducing hospital stay time and avoid re admissions. It also has a significant effect on dramatically reducing healthcare cost and improving quality of care.

Step 2 Clustering of IoT devices:

The phase 2 process has taken place to gathering IoT devices bandwidth from smart home based IoT devices such as baby monitoring, remote healthcare, thermostat, smart lock, smart watch, smart surveillance system. Over the period, bandwidth usage of 15 IoT devices under smart home category taken from smart home router bandwidth logs.

Step 3 – Collection of Bandwidth Data

Bandwidth usage log obtained from smart home based IoT devices put into clustering techniques for pattern analysis. Billions of IoT devices equipped with sensor expected to connect with internet. Clusters are formed from devices that are close in terms of bandwidth usage pattern. Prominent Clustering technique applied to preprocess the raw dataset before categorizing the IoT cluster more clearly. Since scaling attributes varies widely, clustering parameter measured in terms of bandwidth usage in Mbps. Optimal cluster numbers attained through clustering techniques for bandwidth ranges from 0.1 to 10 Mbps. Finally the IoT devices clustered into three categories named as massive, medium and Critical IoT.

Step 4 – Intelligent Model

Once the IoT devices classified into three categories, machine learning models applied on each category to obtain on demand bandwidth prediction for category wise. Learning model find the pattern in categorized data such as low, medium, high and idle state. The performance of training process is a model of machine learning which could be used to make predictions. Regression analysis applied here for estimating the relationship between bandwidth usage model and on demand prediction for IoT clusters.

Regression model finds the threshold and peak load in each category along with the regression analysis shows correlation between a dependent variable and a set of independent variables depending on the cluster dataset. Finally, rules extracted based on machine learning model applied on cluster head that ensuring quality of service by proving continuous service to all IoT devices even with low bandwidth.

Step 5 Optimization of Results

IDBA technique handles the bandwidth management efficiently based on the traffic rules generated by machine learning models. IDBA technique consisting of four stages: Processing, Optimization, Validation and Deployment. IDBA technique process the data according to cluster category rules. It optimizes the data based on input, on demand prediction and throughput. In validation stage the trained model is evaluated with testing dataset such as low, medium, high, and idle range. Deployment is the technique of incorporating the machine learning model with existing delivering technique to make optimistic bandwidth management systems.

Step 6 Parameter Evaluation

Network connectivity and reliable service both are backbone of IoT. In IDBA technique

the QoS is accomplished by maintaining the following parameters Ideal bandwidth usage, reducing delay and increasing throughput. In Ideal bandwidth usage policy, each device gets its share, in case on demand occurs, instead adding bandwidth further, bandwidth allocated from idle devices. Reducing delay an important factor in IoT devices, where critical IoT devices cannot withstand latency. Here, reliability of IoT network measured in terms of throughput. Where further efficiency of IDBA technique reveled with throughput results. Overall performance shows that IDBA technique improving Quality of Service factors in IoT in terms of ideal bandwidth usage, low delay, less packet loss, increasing throughput. Architecture flow revel the efficiency of IDBA technique in providing continuous and stable link to IoT devices through machine learning model.

8. Expected Outcome of the Research Work

For optimal bandwidth management provisioning in IoT devices, an Improved Dynamic Bandwidth Allocation (IDBA) technique is presented. Although, there are several application areas in IoT, however, smart home based IoT devices dataset used as input, K-Means clustering algorithm grouped the IoT devices into three categories based on bandwidth usage pattern. It may be used for clusters the devices. The linear regression technique would be applied over cluster based IoT devices to get on-demand bandwidth for each cluster category. On demand prediction value obtained through the linear regression technique used in Artificial intelligence enabled bandwidth allocation technique. Finally, an artificial intelligence enabled IDBA technique allocates the bandwidth dynamically with a high degree of precision and improves the Quality of Service in IoT devices.

9. Month wise Plan of the Work

Year	2019		2020		2021		2022	
Semester	**SEM- I**	**SEM -II**	**SEM-III**	**SEM-IV**	**SEM-V**	**SEM-VI**	**SEM-VII**	**SEM-VIII**
Course Work								
Literature Survey and Problem Identification								
Review Work and Problem Design								
Existing Methodology Implementation								
Algorithm for Coding and Testing								
Implementation and Results								
Documentation								
Final Documentation and Thesis Write up								
Paper Publication in Reputed Journal and International Conferences								

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